CERTIFICATION UNDER 37 CFR 1.10

I hereby certify that this New Application Transmittal and the documents referred to as enclosed therein are being deposited with the United States Postal Service on this date. 8/24/98 *, in an envelope as "Express Mail Post Office to Addressee," mailing label no. EE412764117US, addressed to: Assistant Commissioner for Patents, Box PATENT APPLICATION, Washington, D.C. 20231.*

Beth Mulcahy
Signature

Assistant Commissioner for Patents
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Washington, D.C. 20231

NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of:

Inventor(s): IMRAN HASHIM, SHE-KWANG LEE, THOMAS BREZOCZKY, and SESH RAMASWAMI

For: COLLIMATED AND LONG THROUGH MAGNETRON SPUTTERING OF NICKEL/IRON FILSM FOR MAGNETIC RECORDING HEAD APPLICATIONS

Enclosed are:

- [X] Specification, Claims and Abstract
- [X] Six (6) Sheet(s) of INFORMAL Drawings
- [X] Combined Declaration and Power of Attorney
- [ ] Information Disclosure Statement (37 CFR 1.98)
- [ ] Art Cited by Applicant (Form PTO-1449)
- [ ] Cited References
- [X] Assignment of Invention to Applied Materials, Inc.
- [X] Recordation Cover Sheet (Form PTO-1595) (**in duplicate)**

The **large-entity** filing fee has been calculated as shown below:

	NO. FILED	LESS NO. PAID BY BASIC FEE	NO. EXTRA (Not less than zero)	
BASIC FEE				790.00
TOTAL CLAIMS	20	20	x 22 =	-0-
INDEP. CLAIMS	4	3	x 82 =	82.00
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIMS +270				-0-
Total:				872.00

[ ] Check number ___ in the amount of $872.00 is enclosed for the filing fee and check number ____ in the amount of $40.00 is enclosed for the assignment filing fee.

[ ] **Please charge Deposit Account No. 01-1651/_____ the amount of $_____ for the filing fee and $40.00 for the recordation of the assignment. (A duplicate copy of this transmittal is enclosed.)**

[X] The Commissioner is hereby authorized to charge payment of the following fees associated with this communication, or credit any overpayment, to Deposit Account No. 01-1651/AMAT/2406/MD/PVD/DV.

[X] Any additional fees required under 37 CFR 1.16.

[X] Any patent application processing fees under 37 CFR 1.17.

[X] The Commissioner is hereby authorized to charge payment of the following fees during the pendency of this application or credit any overpayment to Deposit Account No. 01-1651/ AMAT/2406/MD/PVD/DV.

[X] Any filing fees under 37 CFR 1.16 for presentation of extra claims.

[X] Any patent application processing fees under 37 CFR 1.17.

[ ] The issue fee set in 37 CFR 1.18 at or before mailing of the Notice of Allowance, pursuant to 37 CFR 1.31(b).

Respectfully submitted,

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UNITED STATES PATENT APPLICATION

FOR

COLLIMATED AND LONG THROW MAGNETRON SPUTTERING OF NICKEL/IRON FILMS FOR MAGNETIC RECORDING HEAD APPLICATIONS

INVENTORS:

IMRAN HASHIM
SEH-KWANG LEE
THOMAS BREZOCZKY
SESH RAMASWAMI

CERTIFICATE OF MAILING BY EXPRESS MAIL

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~~Robert W. Mulcahy~~ Beth B Mulcahy

Signature

5-24-1998

Date of Signature

PATENT
Atty. Dkt. 2406/MD/PVD/DV
Express Mail No. EE412764117US

COLLIMATED AND LONG THROW MAGNETRON SPUTTERING OF NICKEL/IRON FILMS FOR MAGNETIC RECORDING HEAD APPLICATIONS

Field of the Invention

The present invention relates to an apparatus and method for forming magnetic recording heads. More particularly, the present invention relates to providing a parallel magnetic field at a substrate during sputter deposition of a metal film onto the substrate.

Background of the Invention

Magnetic read-write heads are used in the recording and retrieval of digital information from magnetic discs, magnetic tape, or other information storage devices. The magnetic heads typically include one or more thin layers of magnetic material that is oriented to generate a magnetic field that alters the recording media, or to sense a magnetic field on the recording media without interference. The thin layer of magnetic material is typically deposited on a substrate that is used to prepare the magnetic recording head.

Figure 1 (prior art) illustrates a typical magnetoresistive head 5 that reads information from magnetic medium 6. The magnetoresistive head 5 includes a soft magnetic layer 7 (*e.g.*, 80% nickel, 20% iron) that functions as the magnetoresistive sense layer, and a hard magnetic layer 8 (e.g., 75% nickel, 20% iron, 5% chromium). The magnetic layers are deposited on a non-magnetic substrate 4 such as aluminum oxide or an alloy of aluminum/titanium/carbon. The soft magnetic layer 7, and the hard magnetic layer 8, are separated by a spacer layer 9 (*e.g.*, tantalum). The magnetic layers are typically manufactured by sputtering a target comprising the metal alloy to deposit particles of the metal alloy onto a substrate positioned within a magnetic field. The magnetic field orients the depositing particles and magnetizes the deposited film. Performance of the magnetic heads is enhanced by depositing the thin film within a substantially parallel magnetic field, as described in United States Patent No. 5,589,039. Sputtering of the target can occur within a magnetic field as known in the art. However, uniform magnetic fields having a high degree of parallelism at a substrate are difficult to maintain within a sputtering chamber because of interference between the magnetic field at the substrate and a plasma generated within a magnetic field at the target.

United States Patent No. 5,660,744 describes a circular magnet array that is located outside an etch chamber and includes a plurality of magnets that form a parallel magnetic field. In the '744 patent, two external circular magnet arrays are used in conjunction with an electric field to enhance an etching process. The circular magnet arrays generate parallel magnetic fields that are out of phase and are not positioned to form a parallel magnetic field at a surface of a substrate.

Elimination of interference between a plasma generated adjacent a metal alloy target and a parallel magnetic field at the surface of a substrate would substantially improve the manufacture of magnetic films such as used in magnetoresistive heads. Therefore, there is a need for a sputtering chamber that provides a parallel magnetic field at the substrate surface without substantial interference from charged particles.

Summary of the Invention

The present invention provides an apparatus and method for sputter depositing a magnetic film on a substrate to produce a magnetic device such as a magnetic recording head for reading and writing digital information on a storage device. The apparatus of the invention includes a sputtering chamber containing a target and a substrate, and a magnet array disposed within the chamber to form a substantially parallel magnetic field at a surface of the substrate. The target and the magnet array are separated by distance and/or a grounded collimator to reduce interference with the parallel magnetic field. The target can be any material that retains magnetic properties when deposited on a substrate positioned in a magnetic field. However, the target preferably comprises a nickel/iron alloy, such as Permalloy metals, suitable for forming magnetic recording heads.

In one embodiment, a sputtering process deposits a magnetic film in a chamber containing a grounded collimator that reduces interference between a plasma generated in a magnetic field adjacent the target and the parallel magnetic field at the surface of the substrate. Preferably, the parallel magnetic field is generated by a circular magnet array. In another embodiment of the invention, a long throw sputtering process deposits a magnetic film in a chamber having a long through distance between the target and the magnet array disposed adjacent the substrate. The long throw process may optionally include a grounded collimator and the circular magnet array.

Brief Description of the Drawings

So that the manner in which the above recited features, advantages and objects of the present invention are attained and can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to the embodiments thereof which are illustrated in the appended drawings.

It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefor not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

Figure 1 (prior art) is a schematic view of a typical magnetic recording head utilizing a magnetoresistive sense layer produced by sputtering metal alloys onto a non-magnetic substrate;

Figure 2 is a schematic sectional view of a sputtering chamber having a grounded collimator that reduces interference with a parallel magnetic field formed at the surface of a substrate by a circular magnet array;

Figure 3 is a schematic view of the circular magnet array that surrounds a substrate surface in the deposition chamber of Figure 2;

Figure 4 is a schematic sectional view of a long throw sputter deposition chamber that substantially reduces interference with a parallel magnetic field formed by a circular magnet array without a collimator;

Figure 5 illustrates the effect of chamber pressure on the easy axis coercivity of a magnetic film deposited in a parallel magnetic field;

Figure 6 illustrates the effect of chamber pressure on the magnetoresistance of a magnetic film deposited in a parallel magnetic field; and

Figure 7 is a B-H curve for an oriented Nickel/Iron Film deposited in accordance with the present invention.

Detailed Description of the Invention

The apparatus and method of the invention substantially improves deposition of magnetic films on a substrate by reducing interference with a parallel magnetic field provided at the surface of the substrate. The magnetic films are deposited in a sputtering chamber typically comprising a sputtering target and a magnet array that magnetizes a thin

film of the target material deposited on a surface of the substrate. Figure 2 is a schematic sectional view of a preferred sputtering chamber of the present invention having a metal alloy target positioned to deposit a thin film on the surface of a substrate, and further including a grounded collimator that reduces interference with the parallel magnetic field.

The sputtering chamber

Referring to Figure 2, a grounded collimator 12 is disposed between a sputtering target 14 and a semiconductor substrate 16 in a sputter deposition chamber 10. The collimator 12 can comprise a one or more cells as shown in Figure 2, two or more concentric rings, or other configurations known in the art. The collimator 12 blocks a portion of the target particles traveling obliquely with respect to the substrate surface to provide a more uniform and symmetrical flux of deposition material to each location on the substrate. In addition, the collimator 12 assists in trapping charged particles that interfere with a parallel magnetic field positioned adjacent the substrate 16 as described below.

Referring still to Figure 2, the sputtering chamber 10 for practicing the invention generally includes a vacuum chamber enclosure wall 24 having at least one gas inlet 26 connected to a gas source (not shown) and an exhaust outlet 28 connected to an exhaust pump (not shown). A substrate support pedestal 20 is disposed at one end of the chamber 10, and the sputtering target 14 is mounted to the other end of the chamber 10. The target 14 is electrically isolated from the enclosure wall 24 by an insulator 18, and the enclosure wall 24 is preferably grounded, so that a negative voltage may be applied and maintained on the target with respect to the grounded enclosure wall 24. In operation, the substrate 16 is positioned on the support pedestal 20 and a plasma is generated in the chamber 10. Charged particles from the target 14 are substantially neutralized by the grounded collimator 12 prior to deposition on the substrate 16.

The magnet array

Figure 3 is a schematic view of a permanent magnet array 50 having a circular shape that preferably surrounds a substrate surface in the deposition chamber of Figure 2. The permanent magnet array 50 is located within the chamber 10 and provides a parallel

magnetic field at a surface of the substrate 16. The permanent magnet array 50 is known as a Halbach array, and can be an electromagnet or a permanent magnet.

The permanent magnet array 50 comprises segments having different magnetic orientations that combine to form a parallel magnetic field as described in United States Patent No. 5,660,744. The circular magnet array is well known for producing parallel magnetic fields in electric motors. The circular magnet array 50 preferably has 12 or more segments to provide a uniform magnetic field. Placement of the circular magnet array 50 within the chamber walls 24 provides a limited magnetic field that is not substantially impaired by the magnetron 30. Referring to Figure 2, placement of the grounded collimator 12 between the magnetron 30 and the magnet array 50 in the long throw chamber 10 as shown eliminates interference by the magnetron 30 with the parallel field at the substrate.

In the alternative, the magnet array could have a non-circular configuration as shown in United States Patent No. 5,589,039, particularly when used in combination with the grounded collimator 12 or within a long throw sputtering chamber 10 as described below for an alternate embodiment.

The deposition process

During the deposition process of the present invention, using an apparatus such as described in Figure 2, a process gas comprising a non-reactive species such as Ar, is charged into the vacuum chamber 10 through the gas inlet 26 at a selected flow rate regulated by a mass flow controller (not shown). The chamber pressure is controlled by varying the rate that process gases are pumped through the exhaust outlet 28.

A power source, such as a D.C. power supply 22, applies a negative voltage to the target 14 with respect to the enclosure wall 24 so as to excite the gas into a plasma state. Ions from the plasma bombard the target 14 and sputter atoms and larger particles of target material from the target 14. The particles sputtered from the target 14 travel along linear trajectories from the target 14, and a portion of the particles collide with, and deposit on, the substrate 16.

A conventional magnetron sputtering source employs a rotating magnet 30 above the target 14 to increase the concentration of plasma ions adjacent to the sputtering surface

of the target 14. Rotation of the magnetron 30 during sputtering of the target 14 results in an even erosion profile.

The surfaces of the collimator 12 that are perpendicular to the surface of the substrate 16 block particles travelling obliquely to the surface of the substrate 16 as described in United States Patent No. 5,527,438. Thus, the collimator 12 promotes deposition of target particles traveling normal to the surface of the substrate 16, and such deposition results in columns of deposited material that are easily oriented within the parallel magnetic field maintained at the surface of the substrate. Grounding of the collimator 12 acts as a sink for electrons from the plasma, thus reducing electron bombardment of the substrate, and essentially eliminates interference between the plasma generated by the magnetron 30 and the magnetic field generated by the permanent magnet array 50.

The target 14 comprises a material that retains magnetic properties when deposited in a substantially parallel magnetic field. For deposition of magnetic recording heads, the target preferably consists of an alloy of nickel/iron (NiFe) having from 75 to 85 wt% of Ni. Most preferably the target is formed from Permalloy metal which is an optimum NiFe alloy having 80 wt% Ni. Combinations of magnetic layers can be used as discussed for Figure 1.

Preferably, the exposed surfaces of collimator 12 are composed of a material that is non-contaminating to the chamber when exposed to a plasma. Therefore, the collimator 12 is preferably manufactured from the same material as the target 14. The collimator 12 is supported in the chamber 10 between the substrate 16 and target 14 by conventional means and can be in electrical contact with the chamber walls 24 when both are grounded. The collimator 12 can also be rotated within the chamber 24 if desired to reduce build-up of target material on surfaces that face the target 14.

The collimator 12 provides collimation on a gross scale, i.e., it screens from the stream of target particles passing from the target 14 to the substrate 16 a portion of the target particles which are traveling at highly oblique trajectories with respect to the surface of the substrate 16 (i.e., trajectories at low angles relative to the plane of the substrate surface).

An iterative determination of the size and location of the collimator 12, the optimum substrate and target size and spacing, and the optimal magnetron configuration may be performed through trial and error. However, one skilled in the art could also perform the iterations on the properly programmed computer.

Long Throw Sputtering Chamber

Figure 4 is a schematic sectional view of a long throw sputtering chamber that substantially reduces interference with the parallel magnetic field at the surface of the substrate without a collimator. Referring to Figure 4, the long throw sputtering chamber 110 for practicing an embodiment of the invention generally includes the vacuum chamber enclosure wall 124 having the gas inlet 126 and the exhaust outlet 128 connected to an exhaust pump (not shown). The substrate support pedestal 120 is disposed at one end of the chamber 110, and the sputtering target 114 is mounted to the other end of the chamber 110. The target 114 is electrically isolated from the enclosure wall 124 by an insulator 118, and the enclosure wall 124 is preferably grounded, so that a negative voltage may be maintained on the target with respect to the grounded enclosure wall 124. In operation, the substrate 116 is positioned on the support pedestal 120 at a long throw distance from the target 114 of at least 50 mm, preferably at about 80 to 175 mm.

A conventional magnetron sputtering chamber employs the rotating magnet 130 above the target 114 to increase the concentration of plasma ions adjacent to the sputtering surface of the target 114. The magnetron 130 produces a magnetic field that is separated by distance from a parallel magnetic field maintained at the surface of the substrate by the circular magnet array 150 as described above with reference to Figure 3. The long throw distance facilitates reducing interference with the parallel magnetic field. A grounded collimator (not shown) could be included to further reduce interference as described above. Rotation of the magnetron 130 during sputtering of the target 114 results in an even erosion profile.

Method of depositing magnetic films

The apparatus of the invention deposits a magnetic film on the substrate 16, 116 by sputtering the target 14, 114 with a plasma generated adjacent the target, and by

maintaining a surface of the substrate 16, 116 substantially outside the plasma. The substrate 16, 116 is maintained in a magnetic field that is substantially parallel at the substrate surface. The target 14, 114 and the parallel magnetic field is separated by distance and/or a grounded collimator to reduce interference with the substantially parallel magnetic field at the surface of the substrate.

During deposition of a magnetic film, the chamber pressure is maintained below 15 mTorr, preferably below 5 mTorr, to reduce collision of molecules within the chamber 10 and prevent dispersion of the deposited film. The reduced pressure also results in deposited films having a lower content of the processing gas such as argon. Lower argon content significantly improves the deposited film by reducing the easy axis coercivity of the magnetic film. Figure 5 illustrates the effect of chamber pressures ranging from 1 to 20 mTorr on the easy axis coercivity of NiFe magnetic films (80% Ni, 20% Fe) having a thickness ranging from 200 to 1000 Å. Lower argon content also significantly improves the deposited film by increasing the magnetoresistance of the magnetic film. Figure 6 illustrates the effect of chamber pressures ranging from 1 mTorr to 20 mTorr on the magnetoresistance of the NiFe magnetic films of Figure 5.

Nickel/iron alloys, such as Permalloy metal films, are typically deposited on substrates at a thickness less than about 200 Å for magnetoresistive head applications. The magnetic films are deposited on a non-magnetic substrate such as described for Figure 1. The strength of the second magnetic field for a 4 inch substrate is preferably from 50 to 100 gauss, and such a parallel magnetic field is readily provided by a permanent magnet array having an outside diameter less than 12 inches. The combination of reduced interference and the permanent magnet array as described herein results in a parallel magnetic field at the surface of the substrate that is easily aligned with the substrate with less than 1% dispersion.

Example

The present invention was reduced to practice by placing a permanent magnet array within an ENDURA™ PVD chamber in combination with a Permalloy metal target and a substrate comprising aluminum, titanium, and carbon. The substrate had a diameter of 4 inches and the Permalloy metal target had a diameter of 12 inches. The distance

between the target and the substrate was 120 mm during processing. The permanent magnet array was a commercially available Halbach array that had an inside diameter of 9 inches and an outside diameter of 11 inches.

The PVD chamber included a magnetron that generates a magnetic field of 30 gauss adjacent the target. D.C. power of 100 W was applied to the target during deposition.

The deposited film had excellent magnetic properties as shown in Figure 7 indicating that the Halbach array maintained a parallel magnetic field at the surface of the substrate and deposited a highly oriented film. The easy axis hysterisis loop 200 and the hard axis hysterisis loop 210in are well defined in Figure 7, and establish that the deposited film is magnetically oriented.

While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof. The scope of the invention is determined by the claims that follow.

What is claimed is:

1. An apparatus for depositing a magnetic film, comprising:

a sputtering chamber containing a target, a substrate having a surface that is separated from the target, and a grounded collimator positioned between the target and the substrate; and

a magnet array disposed within the chamber to form a substantially parallel magnetic field at the surface of the substrate.

2. The apparatus of claim 2, wherein the target comprises a material that retains magnetic properties when deposited on the surface of the substrate.

3. The apparatus of claim 3, wherein the target is separated from the substrate by a long throw distance of at least 50 mm.

4. The apparatus of claim 4, wherein the magnet array is a circular ring.

5. The apparatus of claim 5, wherein the target comprises a nickel/iron alloy.

6. An apparatus for depositing a magnetic film, comprising:

a sputtering chamber containing a target and a substrate separated by a long throw distance of at least 50 mm; and

a magnet array disposed within the chamber to form a parallel magnetic field at a surface of the substrate.

7. The apparatus of claim 6, further comprising a grounded collimator disposed within the sputtering chamber between the target and the substrate.

8. The apparatus of claim 7, wherein the magnet array is a circular ring.

9. A method for depositing a magnetic film within a sputtering chamber containing a target and a substrate, comprising:

sputtering the target at a chamber pressure less than 15 mTorr; and

maintaining a surface of the substrate at a long throw distance of at least 50 mm from the target and within a magnetic field during sputtering of the target, the magnetic field being substantially parallel at the surface of the substrate.

10. The method of claim 9, further comprising collimating sputtering of the target with a grounded collimator disposed between the target and the substrate.

11. The method of claim 10, wherein the target comprises a Ni/Fe alloy.

12. The method of claim 11, wherein the target is sputtered by a plasma generated in a magnetic field maintained adjacent the target by a magnetron disposed outside the sputtering chamber.

13. The method of claim 12, wherein the parallel magnetic field is generated by a circular magnet array disposed within the sputtering chamber.

14. The method of claim 13, wherein the chamber pressure is less than 5 mTorr.

15. A method for depositing a magnetic film within a sputtering chamber containing a target and a substrate, comprising:

sputtering the target onto a surface of the substrate at a pressure less than 15 mTorr;

collimating sputtering of the target with a grounded collimator disposed between the target and the substrate; and

providing a parallel magnetic field at the surface of the substrate during sputtering.

16. The method of claim 15, wherein the sputtering occurs at a chamber pressure less than 15 mTorr.

17. The method of claim 16, further the parallel magnetic field is provided by a circular ring of magnets disposed within the chamber.

18. The method of claim 17, wherein the target and the surface of substrate are maintained at a long throw distance of at least 50 mm during sputtering.

19. The method of claim 18, wherein the target comprises a Ni/Fe alloy.

20. The method of claim 19, wherein the grounded collimator removes charges from target particles and reduces interference with the parallel magnetic field.

Abstract of the Disclosure

An apparatus and method for sputter depositing a magnetic film on a substrate to produce a magnetic device such as magnetic recording heads for reading digital information from a storage medium. The apparatus of the invention includes a sputtering chamber containing a target and a substrate, and a magnet array disposed within the chamber to form a substantially parallel magnetic field at a surface of the substrate. The sputtering chamber reduces interference between the magnetron and the magnet array by providing a long throw distance and/or a grounded collimator. The magnet array is preferably a circular ring.

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that

This declaration is of the following type:

[X] original
[ ] divisional
[ ] continuation
[ ] continuation-in-part

INVENTORSHIP IDENTIFICATION

My residence, post office address and citizenship are as stated below next to my name. I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

TITLE OF INVENTION

COLLIMATED AND LONG THROW MAGNETRON SPUTTERING OF NICKEL/IRON FILMS FOR MAGNETIC RECORDING HEAD APPLICATIONS

SPECIFICATION IDENTIFICATION

The specification of which:

[X] filed herewith;
[ ] was filed on_____, under Serial No. _____, executed on even date herewith; or
[ ] Express Mail No._____ (Serial No. not yet known)
and was amended on _____ (if applicable)
[ ] was described and claimed in PCT International Application No._____ filed on _____ and as amended under PCT Article 19 on _____.

ACKNOWLEDGMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information I know to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56,

and which is material to the examination of this application; namely, information where there is a substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent, and

[ ] In compliance with this duty there is attached an Information Disclosure Statement in accordance with 37 CFR §1.98.

PRIORITY CLAIM (35 U.S.C. §119)

I hereby claim foreign priority benefits under Title 35, United States Code, §119, of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below, and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

** [X] No such applications have been filed.

[ ] Such applications have been filed as follows:

A. Prior foreign/PCT application(s) filed within 12 mos. (6 mos. for design) prior to this application, and any priority claims under 35 U.S.C. §119

Country/PCT	Application No	Date Filed	Priority Claimed
			[ ] Yes [ ] No
			[ ] Yes [ ] No
			[ ] Yes [ ] No

B. All foreign application(s), if any, filed more than 12 mos. (6 mos for design) prior to this U.S. application
Country:
Application No:
Filing date:

PRIOR CLAIM (35 U.S.C. §120)

I hereby claim the benefit under Title 35, United States Code, Section 120, of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose information that is material to the examination of this application (namely, information where there is substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application.

[X] No such applications have been filed
[ ] Such application have been filed, as follows:

Serial No.	Filing Date	Status: Patented Pending	Status: Abandoned
(None)			

POWER OF ATTORNEY

I hereby appoint the following attorneys and/or agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

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DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and, further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Sec. 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

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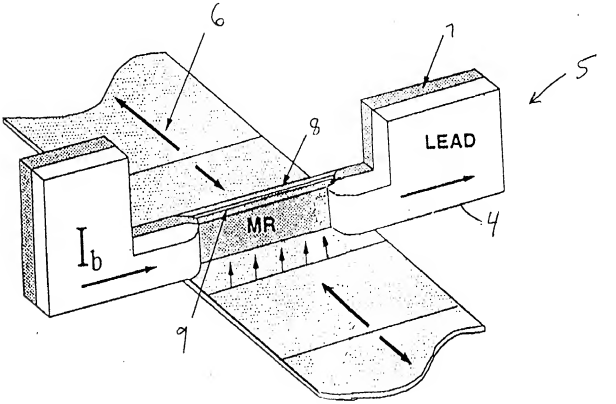
(Declaration ends with this page)

FIG 1

(PRIOR ART)



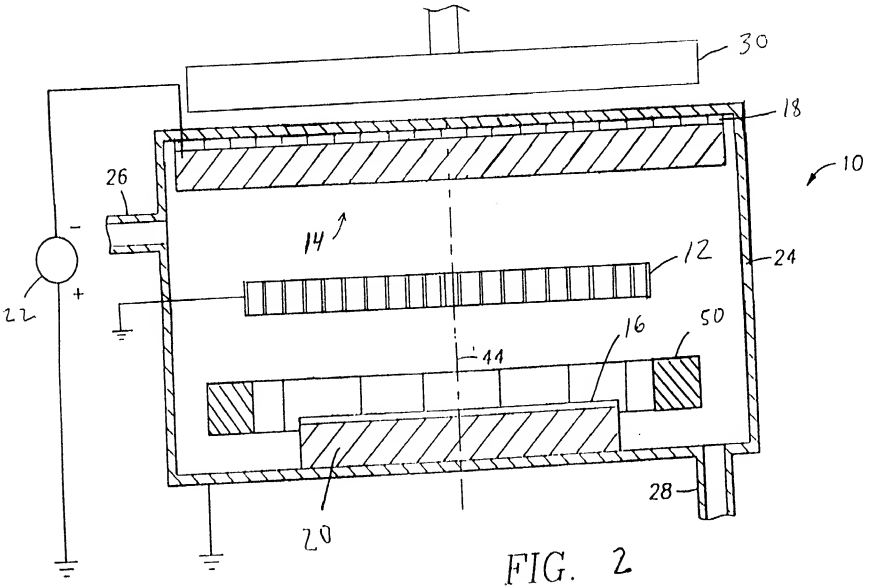


FIG. 2

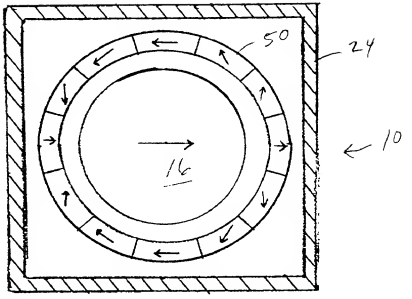


FIG 3

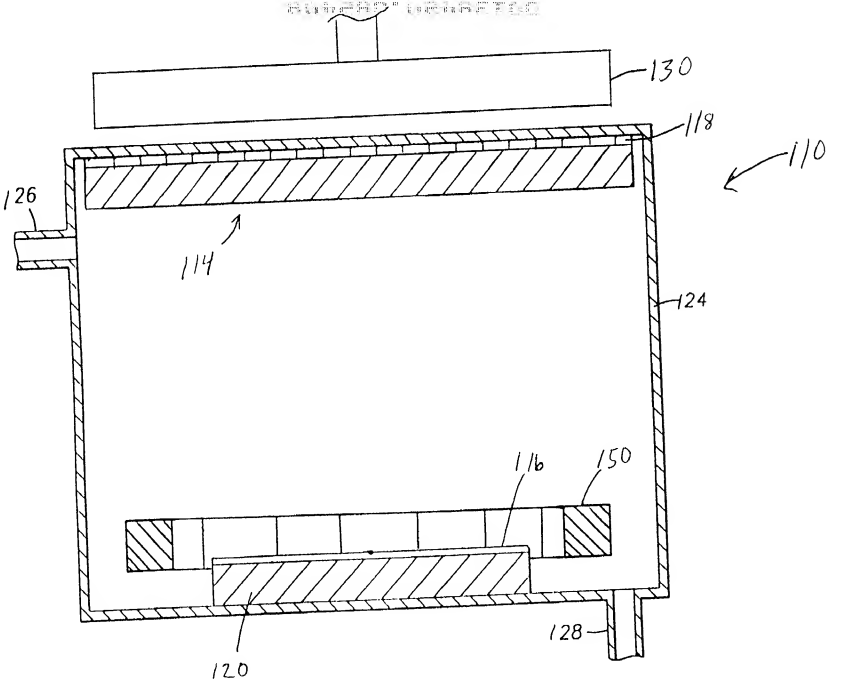
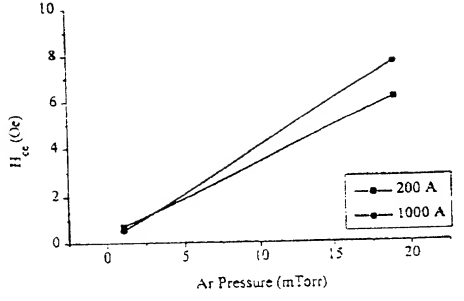


FIG. 4

FIG. 5


10
8
6
4
2
0
H_{cc} ((Oe)
0
5
10
15
20
Ar Pressure (mTorr)
200 A
1000 A

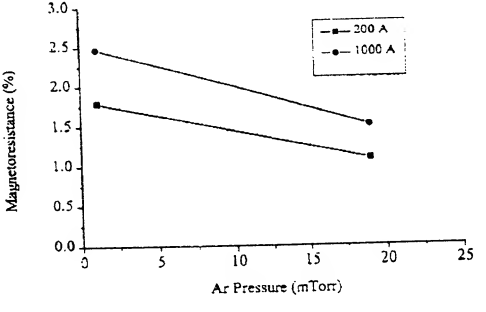

3.0
2.5
2.0
1.5
1.0
0.5
0.0
Magnetoresistance (%)
0
5
10
15
20
25
Ar Pressure (mTorr)
200 A
1000 A

FIG. 6

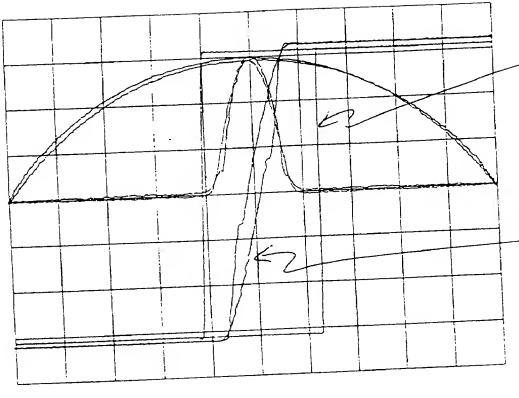


FIG. 7